定期的な運動習慣などのライフスタイル変数を採用した．高次生活機能の自立度の測定は，老研式活動能力指標を用いた．

介入プログラムは，動物性食品摂取や油脂類の摂取を強調した食品摂取の多様性を促すプログラムと運動習慣（自己啓発実践型の自重を活用した筋肉トーニング，およびストレッチ体操）の推進で構成した冊子プログラム「テイクテン」を用い展開した．介入プログラムの実施状況は，地域巡回健康学習会（10回，参加数477名，2004年3月末現在），老人クラブ学習会（16回，508名），栄養尾改善講習会（5回，455名），栄養改善地域伝達講習会（50回，859名），および地域ボランティア学習会（9回，同143名）である．

（倫理面への配慮）

本研究は、財団法人東京都高齢者研究・福祉振興財団東京都老人総合研究所倫理審査要綱に基づいた倫理委員会審査を受けて許可されており、調査対象者本人からはインフォームドコンセントを得て行われた。

C　研究結果

1，ライフスタイル変数

図1に，定期的な運動・スポーツ習慣を有する者の割合の変化を示した．定期的に運動・スポーツ習慣を有するものの割合が有意に増加した．

図2に，定期的な運動・スポーツ習慣を有する者の実施頻度の変化を示した．運動・スポーツの実施頻度が有意に増加した．

図3に，肉類を2日に一回以上食べるものの割合の変化を示した．肉類の摂取頻度が有意に増加した．

図4に，油脂類を2日に一回以上食べるものの割合の変化を示した．油脂類の摂取頻度が有意に増加した．なお，図には示さなかったが，他の主要食品群，魚介類，卵類，牛乳，および緑黄色野菜類の摂取頻度では，有意な変化は認められなかった．

2，栄養指標変数

図5に，介入期間中の血清アルブミンの変化を示した．0.1g/dl 低下し，その変化は有意であった．図には示していないが，総コレステロール，HDL コレステロール，および血色素も有意に低下した．

3，高次生活機能

図6に介入期間中の老研式活動能力指標総合点の変化を示した．有意な得点低下が認められなかった．

D　考察

本地域では，2002年から2003年の1年間に地域在宅の自立高齢者を対象とした運動と食生活習慣を改善する複合プログラム「テイクテン」を用いた介入研究を行った．この先行研究では，運動・スポーツの実施頻度が有意に増加した．伴って，血清アルブミン，総コレステロール，ＨＤＬコレステロールおよび血色素が有意に増加した．これにより本プログラムが加齢に伴う運動習慣の消失予防と低栄養予防に有効なことを実証した．（2004 年日本公衆衛生学会総会，松江，発表）．2003～2004年の1年間では，肉類，油脂類の摂取頻度の有意な増加し，運動習慣を有する者の割合が有意に増加した．加えて，運動習慣を有する者の運動の実施頻度も有意に増加した．しかしながら，血清アルブミン，総コレステロールならびにヘモグロビン等は有意に低下した．すなわち，2002～2003 年に認められた身体栄養状態への介入効果が消失した．この結果は，地域大規模集団への介入の効果の持続の困難さを示しているのかもしれない．

今後，長期にわたる地域大規模介入における介入効果を持続させる手段の開発に着手しなければならない．2005 年度は介入を継続し身体栄養改善活動を推し進め，老化遅延に対する栄養改善地域活動の意義を明確にする．

＜来年度の予定＞

2004年度と同様のデザインで調査し，介入活動を継続する．加えて，介入効果を再現持続させるため，介入方法を再構築し増強する．

E 結論

老化の規定要因は相互に連関しており，筋力を高めるプログラムと栄養改善プログラムを組み合わせることが効果的と考えられる．

F 健康危険情報

特になし

G 研究発表

1. 論文発表

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4) 熊谷修．地域高齢者の栄養改善とスクリーニング．臨床栄養，104，762－768，2004.
5) 熊谷修，他．地域在宅高齢者の身体栄養状態の低下に関連する要因．栄養学雑誌，63（2），（印刷中）．

2. 学会発表

なし

H 知的財産権の出願・登録状況

なし

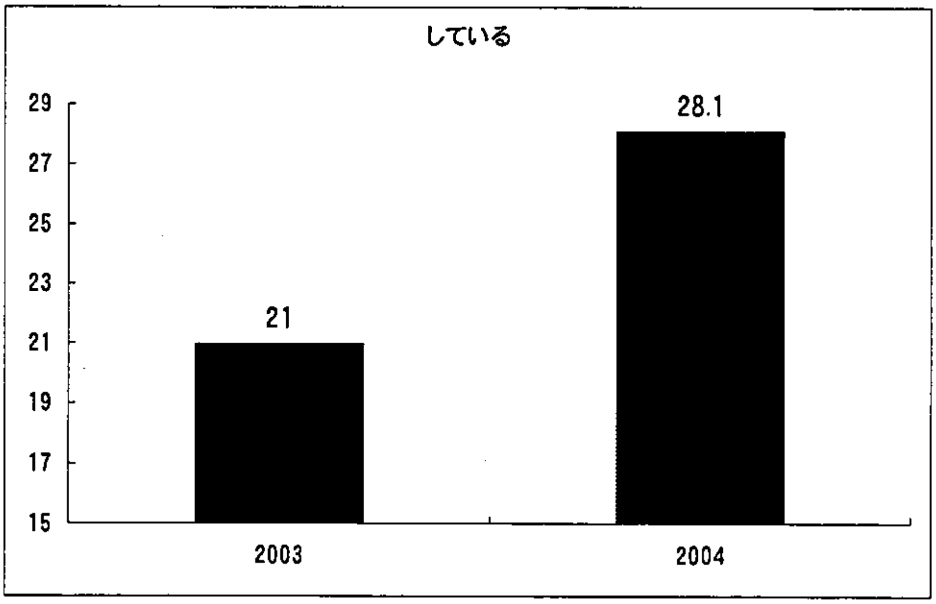

図1 介入期間(2003年以降)の定期的に運動する者の割合(%)の変化
変化は有意(wilcoxon rank sum test. Ｐ＜０．０１，ｎ＝1124)

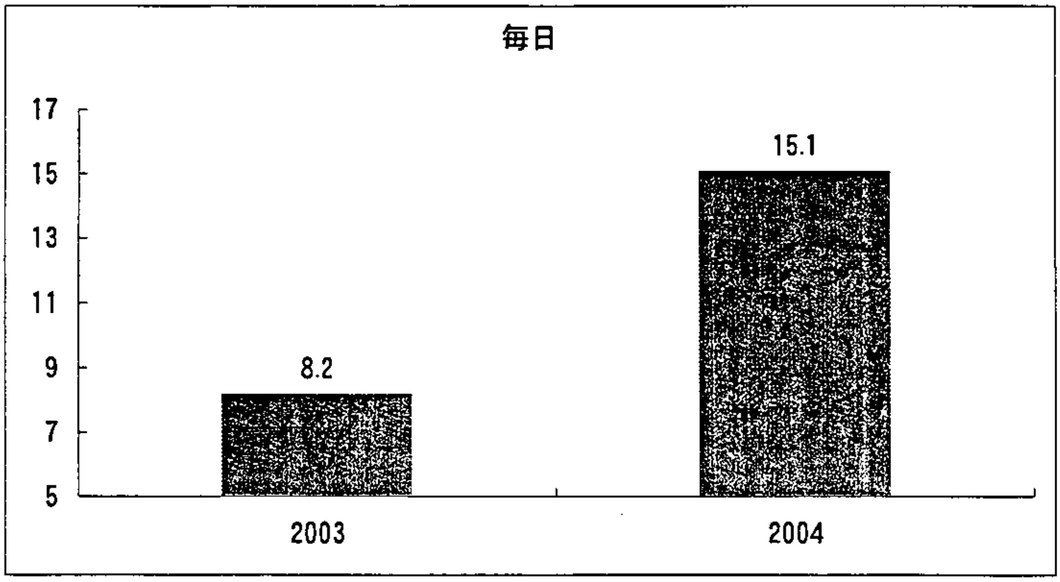

図2 介入期間(2003 年以降)のスポーツ習慣を有する者の実施頻度の変化(毎日行う者の割合の変化(%))
変化は有意(wilcoxon rank sum test. P＜0. 01, n＝161)

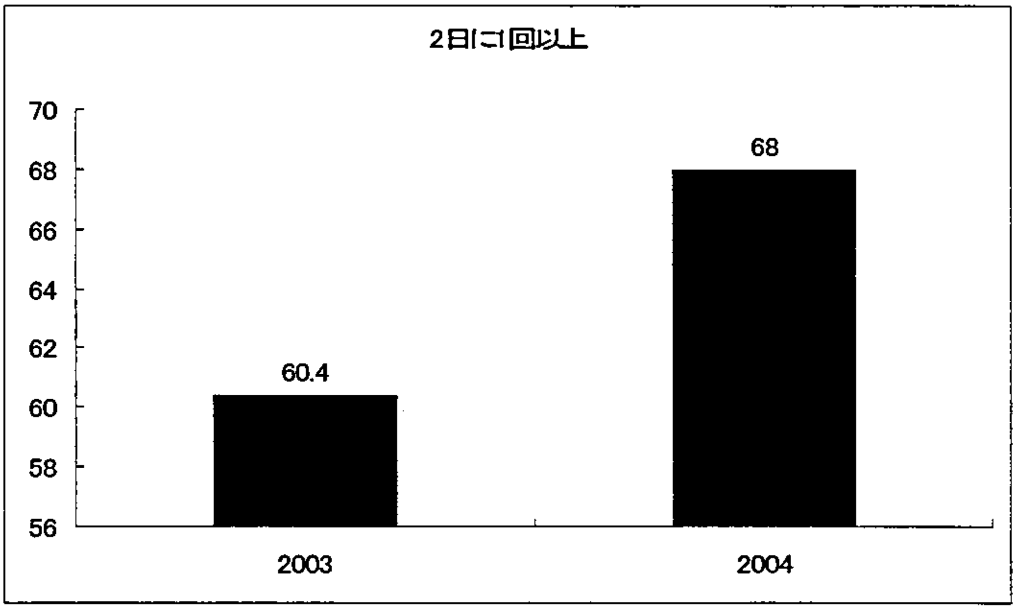

図3 介入期間(2003 年以降)の肉類の摂取頻度の変化
(2日に一回以上摂取する者の割合の変化)
変化は有意(wilcoxon rank sum test. P＜0. 01, n＝938)

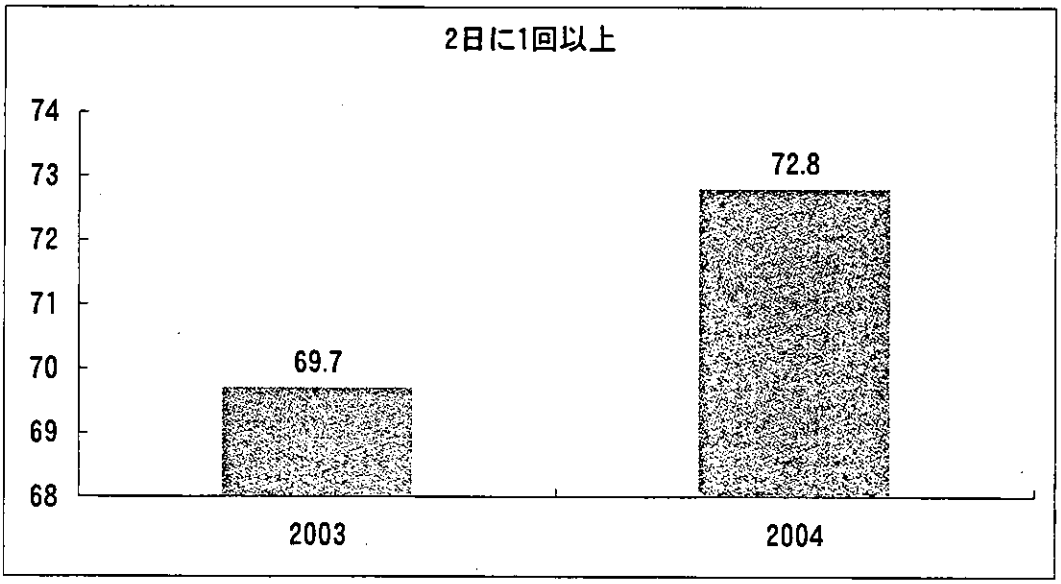

図４ 介入期間(2003 年以降)の油脂類の摂取頻度の変化
（2日に一回以上摂取する者の割合の変化）
変化は有意(wilcoxon rank sum test. P＜0．02，n＝938)

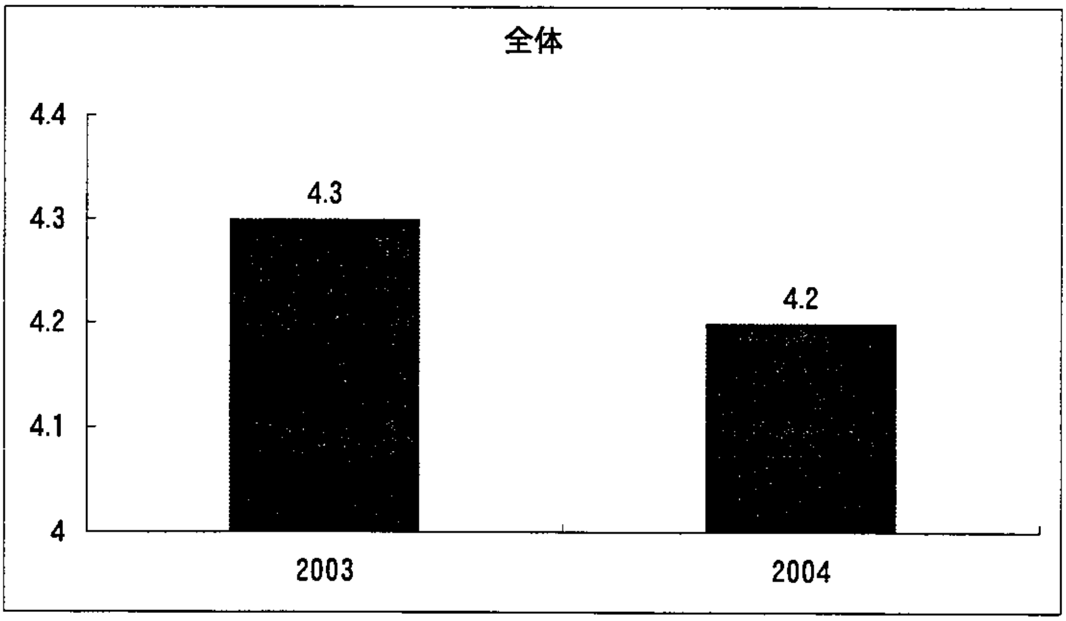

図５ 介入期間(2003 年以降)の血清アルブミン(g/dl)の変化
変化は有意(paired t-test. P＜0．01，n＝795)

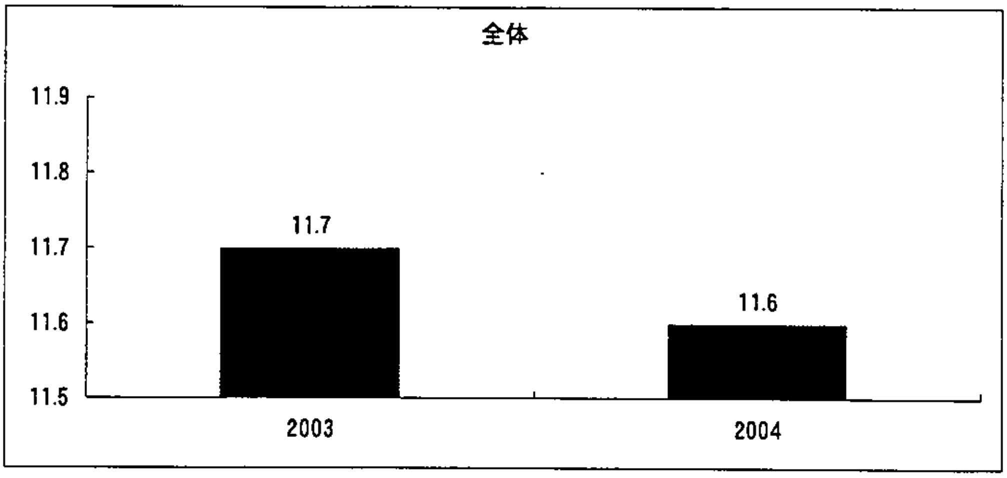

図 6 介入期間(2003 年以降)の老研式活動能力指標総合点の変化
変化は有意ではない（ paired t-test. P＝０．１２，ｎ＝９４０）

研究成果の刊行に関する一覧表

書籍

著者名	論文タイトル	書籍全体の編集者名	書籍名	出版社名	出版地	出版年	ページ
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熊谷修	低栄養予防の重要性. 低栄養予防のポピュレーション戦略		続介護予防完全マニュアル	東京都高齢者研究福祉振興財団	東京	2005	134-45

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発表者名	論文タイトル	発表誌名	巻号	ページ	出版年
Kato Y et al.	Walking duration and habitual exercise related to bone mineral density using computer-assisted X-ray densitometry in Japanese women.	Geriatrics and Gerontology	In press		
Orie Tajima et al.	Two new potent and convenient predictors of mortality in older nursing home residents in Japan.	Geriatrics and Gerontology International	4	77-83	2004
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熊谷修.	地域高齢者の栄養改善とスクリーニング	臨床栄養	104	762-8	2004
熊谷修他	地域在宅高齢者の身体栄養状態の低下に関連する要因	栄養学雑誌	印刷中		

Geriatrics and Gerontology International 2004; **4**: 77–83

ORIGINAL ARTICLE

Two new potent and convenient predictors of mortality in older nursing home residents in Japan

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Background: Malnourishment is closely connected with poor health outcomes in frail elderly. However, the relative importance of specific nutritional predictors of mortality remains unclear in the Japanese population. We investigated the potent nutritional factors associated with mortality from nutritional assessments of three parameters in Japanese frail elderly.

Methods: Ninety residents in a nursing home in Japan, aged 65 and over (18 men, 72 women; mean age 82.2 ± 8.0 years) were enrolled in a 38-month follow-up study. The eligibility condition for analysis was having lived at the nursing home for more than 30 days, so three participants were excluded. Three nutritional parameters, which included: anthropometric measurements (body mass index, mid-arm circumference, triceps skinfold thickness and calf circumference); serum markers (albumin, total protein, prealbumin, retinol binding protein and total cholesterol); and food intake, were assessed. After categorizing each putative factor according to tertile distribution, risk of mortality was analyzed using Cox proportional hazard models.

Results: At the end of the 38-month follow-up period, 29 participants had died. After adjustment for gender, age, clinical status, and functional status, three indicators (i.e. mid-arm circumference, triceps skinfold thickness and lipid intake) showed a significant relationship with mortality. When all of the putative factors were included in a stepwise procedure, mid-arm circumference and lipid intake were significantly associated with adjusted mortality.

Conclusion: Among institutionalized Japanese frail elderly, lower levels of mid-arm circumference and lipid intake could potently predict an increased risk of mortality. These two indicators may be useful for many kinds of assessments and intervention for the improvement of health conditions in Japanese frail elderly.

Keywords: Japanese frail elderly, lipid intake, malnourishment, mid-arm circumference, risk of mortality.

Introduction

Malnourishment and functional disability are closely connected with poor health outcomes in elderly persons.[1-3] Biochemical markers signifying severe malnutrition, such as hypoalbuminemia and hypocholesterolemia, increase the mortality risk in nursing home residents.[2,4-6] Malnourishment, which was assessed by

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anthropometric parameters, including body mass index, weight change, and mid-arm circumference, is reported adversely affect mortality in the frail elderly.[6–9] Among elderly patients with moderate diseases, it is suggested that low food intake is negatively related to 28-month survival.[10] Although malnourishment can be assessed using various parameters,[11] the relative importance of specific nutritional indicators remains unclear. Additionally, few studies have been carried out by concomitantly analyzing the physical parameters and food intake as nutritional predictors of mortality in the frail elderly.[10]

In Japan in 2001, the proportion of the population older than 65 years of age was estimated to be 18.0%.[12] With the rapidly growing number of elderly, there will be a greater need for the care of frail elderly, especially institutionalized people with a high risk of malnutrition. However, there is a paucity of literature about the contribution of nutritional factors to survival in Japanese frail elderly.

The purpose of this study is to investigate the potent nutritional factors associated with mortality based on the nutritional assessment of three parameters, including anthropometric measurements, biochemical markers and food intake. For this purpose, we monitored 38-month survival in a sample of Japanese frail elderly people.

Methods

Participants

Ninety residents in a nursing home in Aichi Prefecture, Japan, aged 65 and over (18 men, 72 women; mean age 82.2 ± 8.0 years), were enrolled in this study with their informed consent and/or that of their guardians. The eligibility for analysis was having lived in the nursing home for more than 30 days.

Protocol

The project was approved by the ethical committee of National Chubu Hospital. Baseline assessment of three nutritional parameters, including anthropometric measurements (body mass index, mid-arm circumference, triceps skinfold thickness, and calf circumference), serum markers (albumin, total protein, prealbumin, retinol binding protein, and total cholesterol) and food intake, were investigated in December, 2000. Nonfasting blood samples were obtained from each subject 3 h after breakfast. Using standardized methods, mid-arm circumference, triceps skinfold thickness and calf circumference were measured by the same physician. The measurements of the arm were made on the nondominant or the nonparetic side for the subjects who have had a cerebro-vascular accident. The dietary intake history of the subjects, based on the menu provided in the nursing home, was investigated by a trained dietitian by interview with the resident and considering additional dietary supplements from the subjects or their carers. On the basis of the dietary history for one month before the anthropometric and biological measurements, the 24-h intake of energy and macronutrients (protein, lipid and carbohydrate) was estimated and calculated as a mean value. Also, additional information on subjects' health status, including number of diseases, number of currently administered drugs and functional status based on the level of care, were examined. Functional status was classified into independent (able to ambulate with or without use of an supportive device), partly dependent (requiring a wheelchair for ambulation) and dependent (usually bedridden).

Data analysis

Mortality data on the date and cause of death were collected over a 38-month follow-up period. For each subject, a time to event and a status variable were created. The status variable indicated whether the event was death or the last follow-up. The relation between each putative nutritional factor and mortality was analyzed using Cox proportional hazard models by computing relative risks and 95% confidence intervals (95% CI). Risk of mortality was assessed and categorized (high, medium or low) according to the tertile distribution of each indicator. Nutrient variables were coded with dummy variables, the reference category being a high level. In order to determine the adjusted association between nutritional indicators and survival, multivariable analyses were also performed by controlling for individual characteristics as confounding factors, including gender, age, disease, drugs and functional status.

Furthermore, the strongest combination of nutritional predictors of survival for the frail elderly was identified. After forcing individual characteristics into a Cox regression model, the stepwise procedure was performed to select significant predictors from all of the putative nutritional parameters examined. Adjusted survival curves were then generated based on the estimated cumulative survivorship functions by the Cox regression model for specific sets of covariate values.

An SPSS statistical package (Statistical Product and Service Solution) was used for all analyses, and statistical significance was established at $P < 0.05$.

Results

Three participants were excluded from the analysis because they had been admitted to the nursing home less than 30 days before the baseline measurements were taken. The remaining participants were followed-up over a 38-month period in the institution. The characteristics of the eligible 87 frail elderly are shown in Table 1. The study population consisted of 17 men and 70 women with an average age of 82.5 ± 7.8 years (range 66–101 years). Almost all of them (97.7%) had some medical problems, including dementia (52.9%), hypertension (26.4%), anemia (26.4%), heart disease (13.8%) and arthritis (6.9%). The subjects had an average 1263 kcal/day of energy intake (men 1412 ± 309 kcal/day, women 1229 ± 324 kcal/day). The proportion of those calories among macronutrients was as follows: 15.5% proteins, 20.7% lipids and 63.8% carbohydrates. The cutoff point for each nutrient indicator was established by its tertile distribution (Table 2).

At the end of the 38-month follow-up period, 29 participants (six men, 23 women) had died, amounting to a cumulative annual death rate of 0.11 per year. The main causes of death in the subjects under study were cardiovascular disease (41.4%) and infection (31.8%). Table 3 presents both unadjusted and adjusted relative risks of death for each nutritional factor we studied. Univariate analysis revealed significant associations with 38-month mortality for all anthropometric measurements, including body mass index, mid-arm circumference, triceps skinfold thickness and calf circumference. Albumin, total protein and prealbumin were independently detected as a significant serum risk factor. Also, low food intake was related to increased risk of mortality in the frail elderly subjects. However, individual factors confounded the associations between each nutrient variable and the mortality risk. After adjustment for gender, age, clinical status and functional status, three indicators, mid-arm circumference, triceps skinfold thickness and lipid intake, showed significant relationships with 38-month mortality (Table 3).

To select the strongest nutritional predictors for survival in frail elderly, the 12 putative nutrient variables we studied were included in a stepwise procedure with the forcing model of the confounding factors (individual characteristics). This Cox regression model demonstrated that mid-arm circumference and low lipid intake are significantly associated with 38-month mortality in the frail elderly (Table 4). Survivorship functions of mid-arm circumference and lipid intake levels after adjustment for the confounding factors are depicted graphically in Fig. 1.

Discussion

The anthropometric characteristics of Japanese nursing home residents we studied seemed to be smaller than

Table 1 Baseline characteristics of subjects (n = 87)

	Mean – SD	% (n)
Individual characteristics		
Gender female	NA	80.5 (70)
Age in years	82.5–7.8	NA
Diseases, n (range)	2.9–1.3 (0–6)	NA
Drugs, n (range)	3.6–2.5 (0–10)	NA
Functional status		
Independent	NA	37.9 (33)
Partly dependent	NA	26.4 (23)
Bedridden	NA	35.6 (31)
Nutritional status		
Anthropometric measurements		
Body mass index, kg/m^2	18.9–4.0	NA
Mid-arm circumference, cm	22.2–3.5	NA
Triceps skinfold thickness, mm	12.5–7.3	NA
Calf circumference, cm	26.0–4.6	NA
Serum markers		
Albumin, g/dL	3.8–0.5	NA
Total protein, g/dL	6.5–0.6	NA
Prealbumin, mg/dL	20.4–5.8	NA
Retinol binding protein, mg/dL	3.1–1.3	NA
Total cholesterol, mg/dL	191.9–37.7	NA
Food intake		
Energy, kcal/day	1263.3–327.7	NA
Protein, g/day	49.0–11.7	NA
Lipids, g/day	29.1–7.5	NA
Carbohydrate, g/day	195.7–54.2	NA

Table 2 Tertiles of nutritional indicators

	Low	Medium	High
Anthropometric measurements			
Body mass index, kg/m^2			
Cutoff	≤ 16.5	16.6–20.1	≥ 20.2
Mean (SD)	14.6 (1.4)	18.7 (1.0)	23.4 (2.6)
Mid-arm circumference, cm			
Cutoff	≤ 20.0	20.1–23.4	≥ 23.5
Mean (SD)	18.2 (1.4)	22.0 (0.7)	25.8 (1.9)
Triceps skinfold thickness, mm			
Cutoff	≤ 8.0	8.1–14.9	≥ 15.0
Mean (SD)	5.2 (1.4)	11.2 (1.7)	21.6 (4.8)
Calf circumference, cm			
Cutoff	≤ 23.6	23.7–28.0	≥ 28.1
Mean (SD)	20.9 (1.9)	26.1 (1.5)	31.2 (2.3)
Serum markers			
Albumin, g/dL			
Cutoff	≤ 3.4	3.5–4.0	≥ 4.1
Mean (SD)	3.1 (0.3)	3.7 (0.2)	4.3 (0.2)
Total protein, g/dL			
Cutoff	≤ 6.3	6.4–6.8	≥ 6.9
Mean (SD)	5.9 (0.4)	6.6 (0.1)	7.2 (0.3)
Prealbumin, mg/dL			
Cutoff	≤ 17.7	17.8–22.4	≥ 22.5
Mean (SD)	14.1 (3.0)	20.2 (1.4)	26.9 (2.5)
Retinol binding protein, mg/dL			
Cutoff	≤ 2.3	2.4–3.3	≥ 3.4
Mean (SD)	1.8 (0.4)	(0.3)	4.6 (0.9)
Total cholesterol, mg/dL			
Cutoff	≤ 173.0	173.1–202.0	≥ 202.1
Mean (SD)	153.3 (14.6)	186.5 (8.9)	236.0 (22.2)
Food intake			
Protein, g/day			
Cutoff	≤ 41.4	41.5–56.3	≥ 56.4
Mean (SD)	36.7 (5.5)	47.7 (4.4)	62.9 (3.9)
Lipids, g/day			
Cutoff	≤ 25.0	25.1–33.0	≥ 33.1
Mean (SD)	21.6 (4.2)	28.6 (2.4)	37.8 (2.1)
Carbohydrate, g/day			
Cutoff	≤ 165.0	165.1–210.0	≥ 210.1
Mean (SD)	142.7 (24.8)	185.6 (12.4)	260.8 (29.1)

those of Canadian and European frail elderly populations.[9,10,13] Moreover, the quantity and proportion of macronutrients in daily food intake among our subjects differed from nursing home residents in Italy.[10] In addition, Japan has a relatively higher percentage of residents with a low level of activities of daily living (ADL) than their US and European counterparts.[14] Nevertheless, the values of biochemical markers for nutritional status in our subjects were consistent with those in European frail elderly.[10] The heterogeneity of physical or nutritional characteristics may therefore imply the importance of a population-specific indicator of nutritional status that could predict health-related outcomes or mortality. However, as in previous reports in European populations,[6,10] we demonstrated that univariate predictors of mortality included mid-arm circumference, triceps skinfold thickness and lipid intake after controlling for functional and other physical parameters.

It is evident that functional disability and malnourishment can be strongly connected with mortality in elderly persons.[1–3] Matsubayashi *et al.* have reported a

Table 3 Association of putative nutritional variables with survival for 38 months in nursing home residents

	Unadjusted Relative risk (95% CI)	*P*	Adjusted for confounders Relative risk (95% CI)	*P*
Anthropometric measurements				
Body mass index		0.007		0.147
Low	3.524 (1.376–9.023)	0.009	2.795 (0.823–9.496)	0.099
Medium	1.174 (0.394–3.496)	0.773	1.021 (0.324–3.217)	0.971
Mid-arm circumference		0.003		0.018
Low	7.707 (2.226–26.680)	0.001	8.404 (1.930–36.600)	0.005
Medium	3.345 (0.887–12.617)	0.075	3.569 (0.936–13.608)	0.062
Triceps skinfold thickness		0.011		0.045
Low	9.127 (2.071–40.216)	0.003	7.391 (1.501–36.403)	0.014
Medium	5.265 (1.153–24.048)	0.032	4.595 (0.944–22.357)	0.059
Calf circumference		0.030		0.406
Low	4.181 (1.374–12.719)	0.012	3.144 (0.587–16.832)	0.181
Medium	2.152 (0.648–7.148)	0.211	1.781 (0.442–7.178)	0.417
Serum markers				
Albumin		0.002		0.060
Low	5.478 (1.984–15.126)	0.001	3.709 (0.883–15.575)	0.073
Medium	2.171 (0.728–6.479)	0.165	1.304 (0.358–4.750)	0.687
Total protein		0.029		0.704
Low	3.557 (1.279–9.887)	0.015	1.611 (0.503–5.162)	0.422
Medium	1.668 (0.570–4.881)	0.350	1.211 (0.401–3.653)	0.734
Prealbumin		0.026		0.401
Low	2.802 (1.140–6.887)	0.025	1.701 (0.654–4.424)	0.276
Medium	1.046 (0.367–2.983)	0.933	0.965 (0.336–2.773)	0.947
Retinol binding protein		0.290		0.892
Low	1.983 (0.810–4.856)	0.134	1.233 (0.472–3.223)	0.669
Medium	1.033 (0.399–2.678)	0.946	1.037 (0.377–2.850)	0.944
Total cholesterol		0.159		0.136
Low	1.478 (0.648–3.374)	0.353	0.851 (0.333–2.175)	0.736
Medium	0.577 (0.210–1.588)	0.287	0.351 (0.115–1.073)	0.066
Food intake				
Protein		0.083		0.471
Low	3.221 (1.146–9.049)	0.026	2.025 (0.600–6.832)	0.256
Medium	2.129 (0.713–6.355)	0.176	2.038 (0.602–6.905)	0.253
Lipid		0.001		0.013
Low	7.479 (2.198–25.451)	0.001	6.972 (1.593–30.507)	0.010
Medium	2.414 (0.604–9.652)	0.213	2.522 (0.544–11.692)	0.237
Carbohydrate		0.027		0.148
Low	4.455 (1.464–13.558)	0.009	3.694 (0.889–15.347)	0.072
Medium	2.521 (0.776–8.186)	0.124	1.944 (0.505–7.475)	0.334

significant association between ADL dependency and death in community-dwelling elderly Japanese.[15] In our study of nursing home residents, the relative risks of mortality for partly dependent and dependent were 2.087 (95% CI; 0.724–6.017, $P = 0.173$) and 3.200 (95% CI; 1.240–8.254, $P = 0.016$), respectively, when univariately analyzed. This result supports previous findings that lower levels of functional status may increase the risk of mortality. However, forcing physical parameters, except for nutritional variables, into the Cox regression model did not remain the association between functional status and survival among nursing home elderly, suggesting that individual characteristics could be confounding factors.

Among the 12 putative nutritional indicators we studied, mid-arm circumference and low lipid intake were significant predictors of adjusted mortality among Japanese frail elderly. The reason why mid-arm circumference was more sensitive than BMI is unclear. Miller *et al.* reported a similar result, indicating that low corrected

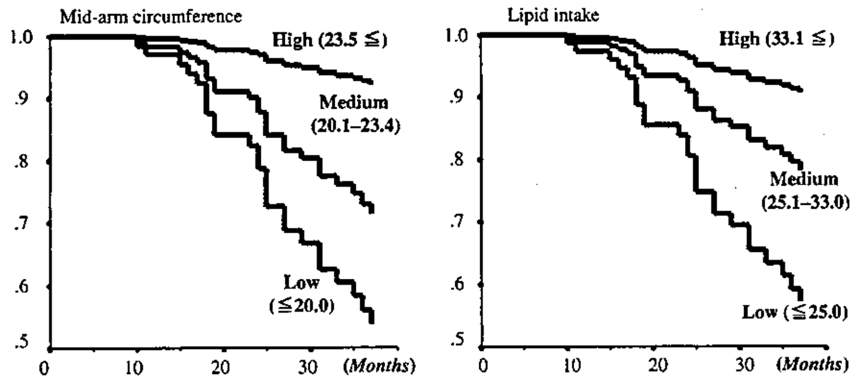

Figure 1 Survivorship functions of lipid intake levels after adjustment for gender, age, clinical and functional status. Survivorship functions are estimated by the Cox regression model for specific sets of covariate values, and the curves represent high (upper curve), medium (middle curve), and low (lower curve), respectively.

Table 4 Nutritional predictors of survival estimated by Cox regression model

	Relative risk (95% CI)	*P*
Individual characteristics†		
Gender, Female	0.351 (0.101–1.215)	0.098
Age, years	1.053 (0.990–1.120)	0.100
Disease, *n*	1.4635 (0.972–2.203)	0.068
Drugs, *n*	0.925 (0.773–1.107)	0.396
Functional status	0.333	
Independent	1.000	
Partly dependent	0.644 (0.179–2.310)	0.499
Bedridden	0.326 (0.070–1.511)	0.152
Nutritional indicators		
Mid-arm circumference		0.039
Low	7.707 (1.595–37.235)	0.011
Medium	4.184 (0.996–17.569)	0.055
Lipid intake		0.055
Low	5.710 (1.149–28.368)	0.033
Medium	2.506 (0.469–13.379)	0.283

†Forced into Cox regression model.

arm muscle area, calculated by mid-arm circumference and triceps skinfold thickness, increased the risk of mortality whereas BMI did not.[16] Age-related reductions in muscle mass are responsible for most of the loss of function in the arm.[17] Additionally, the relationship between mid-arm circumference and deterioration of physical function has been demonstrated.[13] It is plausible therefore that use of one's arm for daily living may result in the maintenance of arm circumference, and that arm mobility might be the most reliable indicator for ADL in predicting mortality in frail subjects.

Low lipid intake was detected as another strong predictor of mortality in our analyzed model. Previous studies suggested that malnutrition resulting from protein-energy deficiency could be associated with increased mortality,[18,19] but there is little direct evidence to support the association. Frisoni *et al.* revealed that decreasing food intake, especially of lipids and protein, was increasingly associated with mortality in frail nursing home patients.[10] They also suggested the relative importance of macronutrients in maintaining the health of frail elderly. Our finding supported the idea that lipid-energy intake as well as protein intake may play an important role in the treatment of malnutrition. Indeed, it is well known that lipid produces energy about two times greater than protein or carbohydrate, and consequently low lipid intake is considered to be an important factor in low energy intake. In the present investigation, the correlation between lipid intake and total energy was 0.818, and the correlation between lipid intake and protein intake was 0.861. These findings suggested that sufficient lipid intake implied sufficient intake of both protein and total energy.

Food intake reduction may impact on organ system functioning, thus directly contributing to poor health outcomes. Implementation of nutritional support will possibly improve survival in frail elderly, because the decrease in food intake could be an early sign of worsening health. In the data from the present study, the relative risk for mortality in frail elderly persons with low lipid intake, defined as less than 25 g/day by the tertile distribution, was about 5.7 times compared to those with high lipid intake. The recommended dietary allowance (RDA) for Japanese elderly (aged 70 or over) suggests that the basal metabolic energy is 1220 and 1010 kcal/day for men and women, respectively.[20] A rate of lipid to total energy of 20–25% is also recommended.[20] The lowest lipid/energy rate (20%) for basal metabolic energy in female elderly (1010 kcal/day) is equivalent to a lipid intake of 25 g/day. Therefore, the implication of our result is that a nutritional intervention strategy assuring more than 25 g/day of lipid intake be recommended so as to improve health conditions among Japanese frail elderly.

There are a few limitations in the present study. First, our sample consisted of only a relatively small number of frail nursing home residents, resulting in a poor statistical power with wide confidence intervals. Our observations must be confirmed in larger samples and in other frail elderly populations. It was difficult to clarify the inter-relationships among nutritional factors with mortality in the present model with such a small sample.

In conclusion, we demonstrated an association between malnutrition and 38-month mortality in Japanese frail elderly. The present results suggest two very potent and convenient predictors of mortality in older nursing home residents. The two indicators, mid-arm circumference and low lipid intake, may be useful for many kinds of assessments and intervention for the improvement of health conditions in Japanese frail elderly. Further studies of Japanese frail elderly are needed to clearly understand the contribution of nutritional status to survival.

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ORIGINAL ARTICLE

Nutritional assessment of elderly Japanese nursing home residents of differing mobility using anthropometric measurements, biochemical indicators and food intake

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Background: Awareness and evaluation of individual nutritional status are required for optimal support of the elderly population. A Japanese Anthropometric Reference Data (JARD 2001) was established as a new gold standard, however, its utility for very frail elderly with differing mobility and the relationship with biochemical parameters and food intake remains unclear. The purpose of this study was to investigate the possible relationship between nutritional status and mobility deficits in Japanese nursing home residents, and to compare the ability of JARD 2001 to detect malnutrition with other indicators.

Methods: In 130 Japanese nursing home residents (26 men, 104 women; mean age 82.2 ± 9.0 years), anthropometric measurements (body mass index, mid-arm circumference, triceps skinfold thickness and calf circumference), serum markers (albumin, total protein, prealbumin, retinol binding protein, total cholesterol, HDL-cholesterol, triglyceride, white blood cells, erythrocyte, hemoglobin and lymphocytes) and food intake were assessed. The nutritional indicators were compared among categories according to severity of mobility deficits, and the ability to detect malnutrition was examined in each parameter.

Results: The bedridden elderly had significantly lower nutritional indicators, including anthropometric indexes, albumin, HDL-cholesterol and food intake, compared with other elderly who can move with or without a wheelchair. When protein-energy malnutrition was defined as below 1.2 g/kg/day protein intake, 36.7% of the residents were considered to have an intake deficiency. The JARD 2001 was better able to identify the deficiency than albumin level in the independent and the chair-bound, while albumin could detect the malnourished subjects more sensitively than anthropometric measurements in the bedridden.

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Conclusion: Poor nutritional indicators could relate with mobility deficits among institutionalized Japanese frail elderly. The ability of indicators to detect malnutrition diverged with the severity of mobility deficits. The JARD 2001 criteria should be adopted for the elderly with at least an ability to move about by wheelchair, and appropriate anthropometric reference standards for very frail people must be reconsidered.

Keywords: Japanese frail elderly, JARD 2001, malnutrition, mobility deficits, nutritional assessment, serum albumin.

Introduction

The number of aged people has increased rapidly in developed countries, and about 18.0% of the Japanese population were aged 65 or older in 2001.[1] Elderly individuals usually have various health problems, such as chronic diseases and physical frailty. In addition to the fact that the amount of daily food intake is an important contributory factor in the progression of frailty, up to 15% of ambulatory outpatients and 25% to 60% of institutionalized elderly have been reported as malnourished.[2–4] Thus, optimal nutritional support, including assessment and intervention, are needed to minimize frailty in the elderly, especially institutionalized people with a high risk of malnutrition.

Malnutrition has been mainly evaluated by anthropometrical and biochemical parameters.[5] Information about nutritional status in nursing home residents with physical frailty, particularly mobility deficits, is still very limited in Japan. Additionally, the specific indicators for nutritional assessment of older patients of differing mobility remain to be analyzed. In 2001, Japanese Anthropometric Reference Data (JARD 2001) were firstly established as a new gold standard for nutritional assessment based on non-invasive methods.[6] It provides the anthropometric norms for healthy men and women in each 5-year age bracket, including over aged 61, and enables evaluations in relation to the body composition. However, the relationship between the JARD 2001 and other nutritional indicators, such as biochemical parameters and food intake, in nutritional assessment has not been examined.

The purpose of this study is to investigate the possible relationship between nutritional status and mobility deficits in Japanese nursing home residents, and to examine the utility of JARD 2001 in nutritional assessment of frail elderly by comparing its ability to detect malnutrition with other nutritional indicators, including biochemical parameters and food intake.

Methods

Participants

Data were obtained from frail elderly living in two nursing homes in Aichi Prefecture, Japan. The study population consisted of 130 participants, including 86 residents from one institute (total of 150 residents) and 44 from another (total of 80 residents). Their informed consent and/or that of their guardians was obtained in writing.

Protocol

The project was approved by the ethical committee of National Chubu Hospital. Anthropometric measurements were taken of height, weight, mid-arm circumference (AC), triceps skinfold thickness (TSF) and calf circumference (CC). Body mass index (BMI) was calculated by a general equation based on the height and weight. Biochemical parameters analyzed included albumin, total protein, prealbumin, retinol binding protein (RBP), total cholesterol, HDL-cholesterol, triglyceride (TG), white blood cells (WBC), erythrocytes (RBC), hemoglobin (Hb) and lymphocytes. The dietary intake history based on the provided menu was investigated by a trained dietitian by interview with the participants or their carers about the residue and additional supplements. On the basis of the dietary history for one month before the anthropometric and biological measurements were taken, the 24-h intake of energy and macronutrients (protein, lipid and carbohydrate) was estimated and calculated as a mean value. Mobility deficits in the present study were classified into three categories modified from the mobility classification of the Japanese Official Long-term Care System:[7] independent (ability to move with or without a supportive device), chair-bound (requiring a wheelchair for movement) and usually bedridden.

Malnutrition was defined with regard to the level of each parameter. The cut-off points of each anthropometric index were defined based on the criteria of JARD 2001 (chapter 6).[6] A patient in the 50th percentile below the norm of age- and sex-matched healthy controls was considered a case of malnutrition if he/she had an ability to move with or without wheelchair (independent and chair-bound). For a patient who requires complete assistance in daily activities (bedridden), fifth percentile below the norm was applied as the criteria for malnutrition. A serum albumin level of 3.5 g/dL was arbitrarily selected as the cut-off point to define malnutrition since it has been widely accepted in previous studies.[8–12] In addition, an individual was classified as nutritionally deficient if their food intake was less than the recommended dietary allowance (RDA) for Japanese elderly (over aged 70). The RDAs of energy and protein intake were estimated as 27–32 kcal/kg/day and 1.1–1.2 g/kg/day, respectively, by calculating according to the basal metabolic energy and the standard body weight for those of the Japanese reference data aged over 70.[13] In this study, thus, we adopted 30 kcal/kg/day for energy and 1.2 g/kg/day for protein as the cut-off point of intake deficiency.

Data analysis

Values are presented as means ± standard deviation (SD). Group differences among the three categories regarding severity of mobility deficits in the nutritional indicators were evaluated using analysis of variance (ANOVA) with Fisher's post hoc test. Additionally, Pearson correlation coefficients between anthropometric indices and biochemical parameters or food intake were calculated by a regression analysis.

An SPSS statistical package (Statistical Product and Service Solution) was used for all analyses, and statistical significance was established at $P < 0.05$.

Results

Sample description

Details of the characteristics of subjects in the present study are given in Table 1. We classified 130 elderly according to the severity of mobility deficits: 23.8% (seven men and 24 women) were independent, 39.2% (12 men and 39 women) were chair-bound, and 36.9% (seven men and 41 women) were bedridden. There were no differences in the distribution between genders, and the mean age did not differ among the three groups. The bedridden included 31 elderly who required assistance in feeding.

Relationship between nutritional status and degree of dependency

Nutritional indicators were compared among the three groups according to the severity of mobility deficits (Table 2). In all anthropometric measurements except for TSF, the bedridden had significantly lower values than other groups. Anthropometric measurements were the same in the independent and the chair-bound. Moreover, the serum albumin level in the bedridden was significantly lower than in the other groups. A significantly lower level of HDL-cholesterol was found in the bedridden compared with the independent. Differences in food intake in relation to mobility deficits are also shown in Table 2. With the gradual progression of deficits, energy intake of protein, lipid and carbohydrate significantly decreased. Carbohydrate intake per body weight (g/kg/day) was lower in the bedridden than in the independent and the chair-bound, whereas there were no differences in the adjusted intakes of protein and lipid among the three groups.

Comparison in detection of malnutrition between JARD 2001 and other nutritional indicators

Anthropometric measurements had a good correlation to serum albumin and prealbumin level (Table 3). Additionally, BMI, AC and CC correlated with food intake.

On the basis of the cut-off points for malnutrition for each indicator, the nutritional status of individuals was assessed. We observed 24.8% to 66.4% of malnourished residents according to the indicators and their criteria (Table 4). Over 70% of the independent were estimated to suffer from malnutrition by the JARD 2001, excluding CC, whereas malnutrition was true in only 4.4% to 35.6% of the bedridden. On the other hand, estimation according to the serum albumin level led to classification of 19.4% of the independent and 58.7% of the bedridden as malnourished. About 30–40% of the subjects with a lower intake than the RDA values of energy and protein were detected, irrespective of severity of mobility deficits. Furthermore, the ability to distinguish protein intake deficiency (< 1.2 g/kg/kcal) was compared between the criteria of the JARD 2001 (AC) and that of the albumin. The cut-off point of the AC could identify 70% and 84.2% of the subjects with low protein intake in the independent and the chair-bound, respectively. Only 25% of the protein-intake deficiency in the bedridden was identified as being malnutrition by the AC. Using the criteria of albumin (< 3.5 g/dL) 52.9% of the

Table 1 Characteristics of subjects

	All	Independent	Chair-bound	Bedridden
n	130	31	51	48
Gender (females), %	80.0	77.4	76.5	85.4
Age, years (SD)	82.2 (9.0)	81.3 (9.0)	81.5 (8.7)	83.4 (9.5)

Table 2 Nutritional status in relation to degree of dependency (mean – SD)

	Independent	Chair-bound	Bedridden
Anthropometric measurements			
Body mass index, kg/m^3	20.2–3.0	19.7–3.7	17.2–3.2*#
Mid-arm circumference, cm	22.4–2.7	21.3–2.9	19.8–2.8*##
Triceps skinfold thickness, mm	10.7–6.7	9.6–5.6	9.1–5.3
Calf circumference, cm	33.6–2.9	31.9–4.7	27.7–4.1*#
Biochemical parameters			
Total protein, g/dL	7.0–0.5	6.9–0.5	6.8–0.6
Albumin, g/dL	3.8–0.4	3.6–0.3	3.4–0.4*#
Prealbumin, mg/dL	19.9–5.7	20.4–5.1	17.9–5.7
Retinol binding protein, mg/dL	3.0–1.2	3.1–1.2	2.8–1.2
Total-cholesterol, mg/dL	206.1–48.4	194.8–33.9	190.9–44.9
HDL-cholesterol, mg/dL	56.8–11.2	53.3–11.8	49.3–12.2**
Triglyceride, mg/dL	102.9–64.7	106.4–53.0	104.1–59.5
White blood cells, $\times 10^2/\mu L$	59.5–12.1	61.6–18.2	63.8–18.2
Erythrocytes, $\times 10^4/\mu L$	381.7–45.5	398.8–58.4	381.9–65.1
Hemoglobin, g/dL	11.7–1.4	11.8–1.5	11.8–1.8
Lymphocytes, per cent	30.4–8.6	28.0–9.0	30.9–9.3
Food intake			
Energy, kcal/day	1538.7–380.8	1376.3–278.0**	1079.7–245.7*#
kcal/kg/day	36.1–9.6	33.7–7.2	31.1–8.9**
Protein, g/day	56.2–11.4	52.0–9.0	44.4–10.9*#
g/kg/day	1.32–0.31	1.28–0.26	1.28–0.41
Lipid, g/day	34.4–6.4	30.6–5.6*	26.6–6.4*#
g/kg/day	0.81–0.18	0.75–0.15	0.76–0.21
Carbohydrate, g/day	246.0–71.9	218.6–48.9**	163.0–40.5*#
g/kg/day	5.77–1.76	5.35–1.24	4.71–1.47*##

*$P < 0.01$; **$P < 0.05$ versus independent; #$P < 0.01$; ##$P < 0.05$ versus partly dependent.

Table 3 Correlation between anthropometric measurements and nutritional parameters

	Anthropometric measurements Body mass index	mid-arm circumference	Triceps skinfold thickness	Calf circumference
Biochemical parameters				
Albumin	0.320*	0.470*	0.238*	0.492*
Prealbumin	0.226**	0.347*	0.248*	0.271*
Total-cholesterol	0.156	0.162	0.120	0.191**
HDL-cholesterol	–0.044	–0.077	–0.198**	–0.073
Food intake				
Energy	0.205**	0.322*	0.143	0.393*
Protein	0.139	0.233*	0.127	0.295*
Lipid	0.220**	0.335*	0.137	0.382*
Carbohydrate	0.199**	0.318*	0.140	0.388*

*$P < 0.01$; **$P < 0.05$.

malnourished subjects could discriminated in the bedridden, whereas there was no relation between protein-intake deficiency and a low albumin level in the independent.

Discussion

Food intake reduction could be an early sign of worsening health. It is also reported that low food intake is

Table 4 Prevalence of malnutrition based on different nutritional parameters

Parameters	Cut-off value	Proportion of malnutrition, % (*n*) Independent	Chair-bound	Bedridden	All
JARD 2001					
Body mass index	50th or 5th percentile of norms	70.0 (21)	66.0 (33)	25.5 (12)	52.0 (66)
Mid-arm circumference	50th or 5th percentile of norms	76.7 (23)	88.0 (44)	35.6 (16)	66.4 (83)
Triceps skinfold thickness	50th or 5th percentile of norms	70.0 (21)	4.4 (2)	66.0 (33)	44.8 (56)
Calf circumference	50th or 5th percentile of norms	20.0 (6)	36.0 (18)	15.6 (7)	24.8 (31)
Biochemical parameter					
Albumin	< 3.5 g/dL	19.4 (6)	33.3 (17)	58.7 (27)	39.1 (50)
Recommended dietary allowance					
Energy	< 30 kcal/kg/day	26.7 (8)	31.4 (16)	42.6 (20)	34.4 (44)
Protein	< 1.2 g/kg/day	33.3 (10)	39.2 (20)	36.2 (17)	36.7 (46)
Prevalence of protein intake deficiency (< 1.2 g/kg/day) according to the parameters					
< 1.2 g/kg/day (n)	–	10	20	17	46
Mid-arm circumference	50th or 5th percentile	70.0 (7)	84.2 (16)	25.0 (4)	60.0 (27)
Albumin	< 3.5 g/dL	0 (0)	20.0 (4)	52.9 (9)	27.7 (13)

negatively related to survival in frail nursing home residents.[14] Nutritional supplementation is more effective in preserving the nutritional state and reducing mortality in previously well-nourished patients than in malnourished ones.[15] Mishima *et al.* reported that, even in bedridden elderly, administration of an enteral diet for 8 weeks served to restore the albumin level.[16] Thus, nutritional supplements may play an important role in health care for all elderly irrespective of their level of frailty, and the awareness and evaluation of the individual nutritional status is required in order to be able to provide optimal support.

Anthropometric measurements and biochemical parameters are useful to assess individual nutritional status.[5] In the present study on nutritional status in relation to severity of mobility deficits, the bedridden elderly had a significantly lower anthropometric index, and lower serum albumin and HDL-cholesterol compared with the independent and the chair-bound. Our findings are consistent with those of a previous report that plasma levels of proteins and lipids, including albumin and HDL-cholesterol, were significantly lower in the bedridden elderly than in outpatients.[16] The relationship between AC and/or albumin level and deterioration of physical function has been well demonstrated in both cross-sectional and longitudinal studies.[16–18] Nevertheless, few studies conducted concomitant evaluations using physical parameters and food intake. In our observation, energy intake, even if adjusted for weight, was lower in the bedridden than in the independent and the chair-bound. The present findings strongly support the suggestion that nutritional status deteriorates with progression in frailty.

There has been no consensus about a standard indicator and definition of malnutrition, despite the importance of nutritional assessment of the frail elderly. Thus, the different prevalence of malnutrition has been detected according to the indices chosen for the assessment and the arbitrary cut-off points for normal and abnormal values.[19,20] In the present study, we found that 24.8% to 66.4% of residents were malnourished according to the indicators and their criteria, whereas the anthropometric measurements correlated with serum albumin or food intake. Furthermore, the ability of indicators to detect malnutrition ranged widely with the severity of mobility deficits. The energy deficit based on the same RDA, for example, for different mobility may over-estimate, since the bedridden elderly have 20–30% lower basal metabolic energy than a control group of elderly.[21] On the other hand, similar rates of protein deficits were detected irrespective of the severity of mobility deficits.

Our study examined the utility of JARD 2001 for nutritional assessment of frail elderly in comparison with other nutritional parameters. When protein-energy malnutrition was defined as below the RDA protein intake (1.2 g/kg/day), 36.7% of the residents were considered to have an intake deficiency. Use of the AC criteria in the JARD 2001 allowed us to identify 70.0% and 84.2% of the independent and the chair-bound, respectively, as deficient. However, in the bedridden, only 25.0% of the deficient elderly were detected using the AC cut-off point. Our results suggest that the JARD 2001 should be adopted for the elderly with at least an ability to move about in a wheelchair. In addition, further research may be necessary to reconsider appropriate anthropometric reference standards for extremely frail people, such as the bedridden.

Anthropometric measurements can be used to reliably and non-invasively evaluate the long-term consequence